CASE STUDY

Coordinated and collaborative application of the mitigation hierarchy in complex multi-use landscapes in Africa: Guinea Central Corridor

Cross-sectoral engagement to mitigate transformational landscape development

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SYNOPSIS

- Emerging development landscape with complexity in the ecological, sociocultural, economic and political contexts and their interactions.
- Unique and highly diverse biodiversity, including high levels of endemism and threatened species and the last viable, intact habitats to support western chimpanzees in West Africa.
- Includes Key Biodiversity Areas and the newly formed Moyen-Bafing National Park, an offset for the Boké Region bauxite mining.
- Numerous classified forests and forest reserves; many do not receive funding nor have dedicated management capacity to achieve conservation objectives.
- Mineral exploration and mining concessions (for bauxite) situated across the landscape, often coinciding with rare montane forest ecosystems and unique and threatened biodiversity.
- Significant hydroelectric power projects with transboundary implications and infrastructure development.
- Unregulated development pressures through smallholder and subsistence agriculture, coupled with very high rates of population growth and a rapidly growing young population are placing increasing pressure on land and natural resources across the landscape.
- New mining projects near the centres or Touqué and Mamou are driving in-migration of people and increased conversion of land to agriculture.
- Identified as a centre of economic development by Government of Guinea.
- Calls for early intervention to apply avoidance and mitigation planning in the anticipated transformational development of the Guinean Central Corridor.
- Identifies key stakeholders needing to collaborate on early stage decision making.
- Encourages sustainable development opportunities in the landscape with maintenance of key biodiversity and ecosystem services values underpinning socioecological dependencies and processes.

CONTENTS

INTRODUCTION

This case study examines an emerging transformational development landscape in the Central Corridor of Guinea, considering complex multi-use ape landscapes and where pressure from concurrent developments on social and natural systems is intensifying or anticipated. The case study applies a conceptual framework that calls for the application of the mitigation hierarchy at both a local and landscape scale and promotes an inclusive and integrated landscape approach to the avoidance, mitigation and management of adverse impacts from development that engages all sectors and scales of activity (Figure 1) (see report produced by FFI, 2021). The framework puts nature firmly at the centre of land use and development planning recognising the fundamental role that healthy, resilient ecosystems play in human health and well-being and sustainable development and is premised on the natural landscape context and underpinned by social and ecological systems. Delivery of the framework requires multi-stakeholder engagement and seeks to promote cross-sectoral and collaborative uptake and application of the mitigation hierarchy. This case study can be read as a standalone document, or with reference to the Conceptual Framework report.

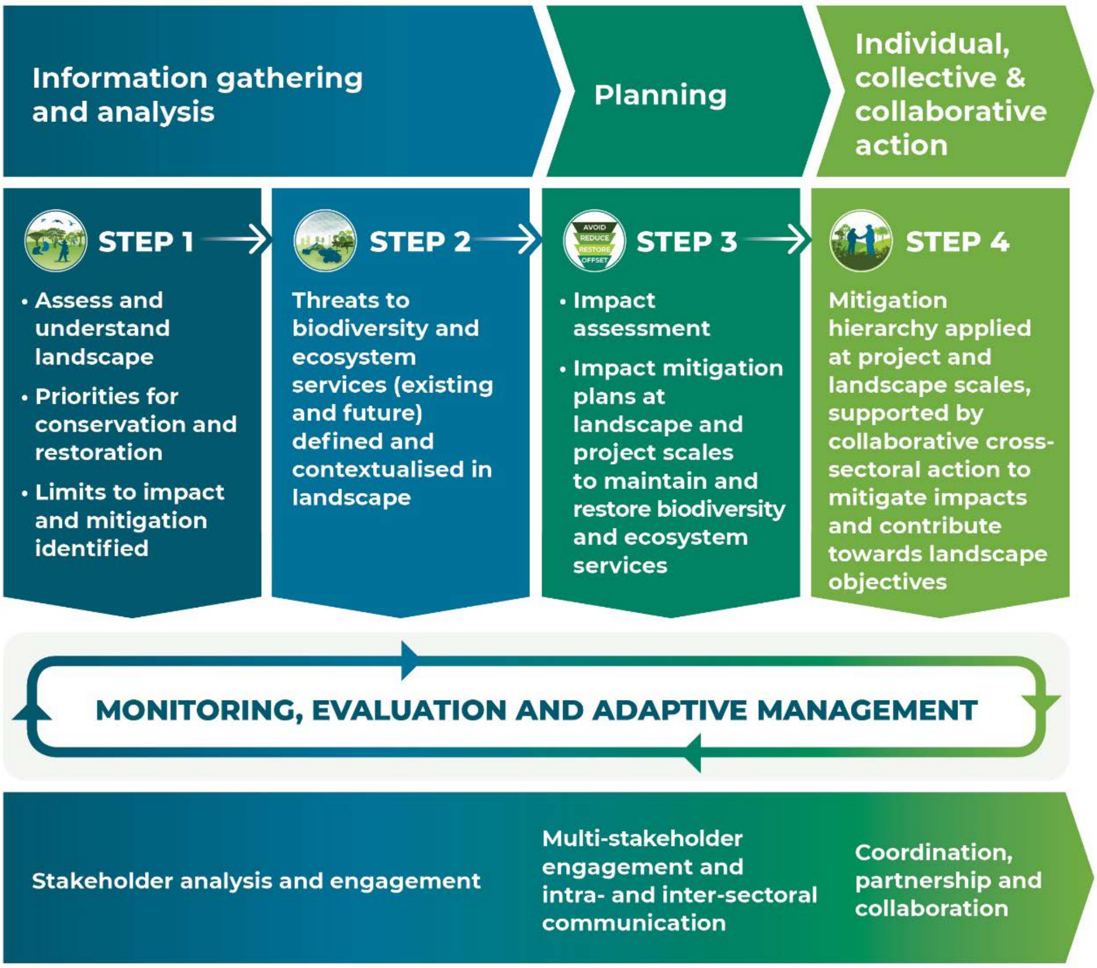

Figure 1 The Conceptual Framework applying the mitigation hierarchy in the landscape

CASE STUDY - GUINEA CENTRAL CORRIDOR

Applying the mitigation hierarchy framework: seeking positive socioecological outcomes in the Guinea Central Corridor

This case study focuses on an early stage pre-mining and agriculture landscape associated with Mamou, within the Fouta Djallon Central Corridor region of Guinea (see Figure 2). Following the four-step framework, opportunities within the landscape are identified for application of the mitigation hierarchy taking into account the socioecological context to protect the integrity and biodiversity values of the landscape. As a highly biodiverse and great ape landscape, particular attention is given to western chimpanzee (*Pan troglodytes verus*) socioecology, particularly to maintain species persistence, ecological intactness and resilience as development enters the Central Corridor.

Context

The Central Guinea Corridor overlaps three provinces (Governorat de Labé, Faranah and Mamou) expanding from Kindia in the south west, through Mamou which provides as an essential infrastructure hub linking to the market towns of Labé, Dalaba, Pita to the north, Touque and Dabola to the north east and Faranah along the corridor to the east. Sierra Leone lies to the south. The western half of the landscape is dominated by the Fouta Djallon Massif (plateau) with the Cene and Bafing Rivers rising in the highlands and flowing north-east, bisecting the landscapes from south west to north east to Mali. The eastern half declines towards the Niger River valley.

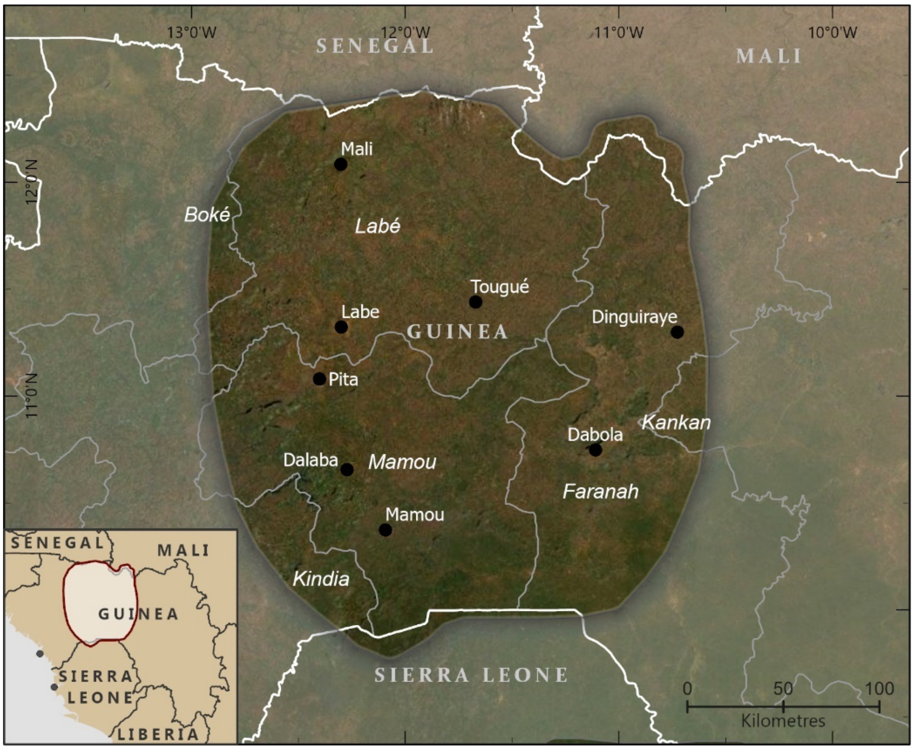

Figure 2 Guinea with focal landscape indicated in red box.

Stakeholder mapping and engagement

Throughout Steps 1 and 2, stakeholders in the landscape have been identified, noted and will be targeted for engagement in the delivery of the principles of this mitigation hierarchy framework. Key stakeholders include:

- Ministry of Mines
- Minister of Energy and Hydraulics of the Republic of Guinea
- Organization for the Development of the Senegal River – (OMVS) Council of Ministers
- Ministry of Environment and Forestry (Protected Areas Authorities, Environmental Centre for the Management of Mounts Nimba and Simandou CEGENS))
- Sub-national authorities of Mamou, Dalaba, Pita, Labé, Tougué
- Anglo African Minerals (AAM)
    - Chief Executive Officer and Project Professional
- ImpactAgri
    - Chief Executive Officer and Project Executives
- OMVS and Sinohydro
    - Koukoutambo Hydropower project
- Local Communities near the mines
    - Community and traditional authorities

These stakeholders will be revisited throughout the application of the Framework and updated and adapted with local and contextual knowledge.

Identify and prioritise features and areas to conserve and restore in the landscape

STEP 1
Assessing and understanding the landscape, identifying conservation and restoration priorities, and setting limits

STEP 1 | STEP 2 | STEP 3 | STEP 4

Biodiversity and ecosystem values

The Central Corridor lies within the Guinean Forests Hotspot which supports impressive levels of biodiversity, including numerous endemic species, making it a conservation priority at the global scale. The hotspot is ranked among the world's foremost regions for mammalian diversity. Nearly one quarter of the mammal species native to continental Africa are represented within the hotspot.
The Central Corridor overlaps with the Guinean Montane Forest and is classified as Regionally Outstanding (Brugiere & Kormos, 2009). The forests have been classified as the

Afromontane archipelago-like regional centre of endemism. The diversity and endemism of many parts of this ecoregion are not well known, however more information should be derived from the baseline studies for the impact assessments of the proposed mining developments, and there is good information for the Moyen-Bafing National Park, a newly declared protected area that is a biodiversity offset for the bauxite mines of the Boke Region (Wild Chimpanzee Foundation, 2018).

Declared in 2018, the Moyen-Bafing National Park, located along the Bafing River, is home to the largest known continuous population of chimpanzees in West Africa. The area of the Moyen-Bafing, overlapping with the prefectures of Tougué, Koubia, Dinguiraye, Dabola and Mamou, encompasses seven classified forests with what now constitutes the largest continuous population of this critically endangered sub-species in West Africa, and one of the largest on the African continent. Moyen-Bafing hosts about 4,000 chimpanzees in an area of 6,426 km^2, the largest protected area for Western chimpanzees in Guinea (Wild Chimpanzee Foundation, 2018). Since 2010, a collaboration was established between Wild Chimp Foundation, Guinean Office of Parks and Reserves, the Guinea Alumina Corporation, the Compagnie de Bauxite de Guinée and the International Finance Corporation (IFC) of the World Bank, with the aim of offsetting the negative effects of mining operations and ensuring the conservation of western chimpanzees in a favourable eco-system.

Two Key Biodiversity Areas (Brugiere & Kormos, 2009) lie within the Central Corridor region: Sincery Oursa (GIN11, 1,586 ha) and Forêt Classée de Balayan Souroumba (GIN3, 22,476 ha). Table 1 and Figure 3 list 48 protected areas in the Central Corridor (UNEP-WCMC, 2021), all of which are Classified Forests apart from the Moyen-Bafing National Park and the Tinkisso Ramsar site.

Table 1 List of protected areas in Central Corridor Guinea

CIRCA MAMOU	CIRCA DALABA	CIRCA DABOLA
Pinselli	Tangama	Bagata
Soyah	Tinka	Diogoure
Koni	Kala	Gueroual
Fitacouna	Fougoumba	Tinkisso
Konkoure Fetto	Damakhania	Souarela
Sere	Mirire	Chutes de Tinkisso
Bantarawei	Djimbera (Bantiguel)	Balayan-Souroumba
Kambia	Circa Kindia	Tinkisso Ramsar site
Gouba	Grandes Chutes	Sincere-Ourssa
Bellel	Damakhania	Circa Labé
Beauvois	Gangan	Dara-Labé
Mnt Balandougou	Sources de Kindia	Galy
Circa Tougué	Sierra-Fore	Mombeya
Darou-salam	Botokoly	Tialakoun
Bani	Souti-Yanfu	Serima
Bakoun		Sala and Haute-Komba
Boula		
Moyen-Bafing National Park		
Sobory		

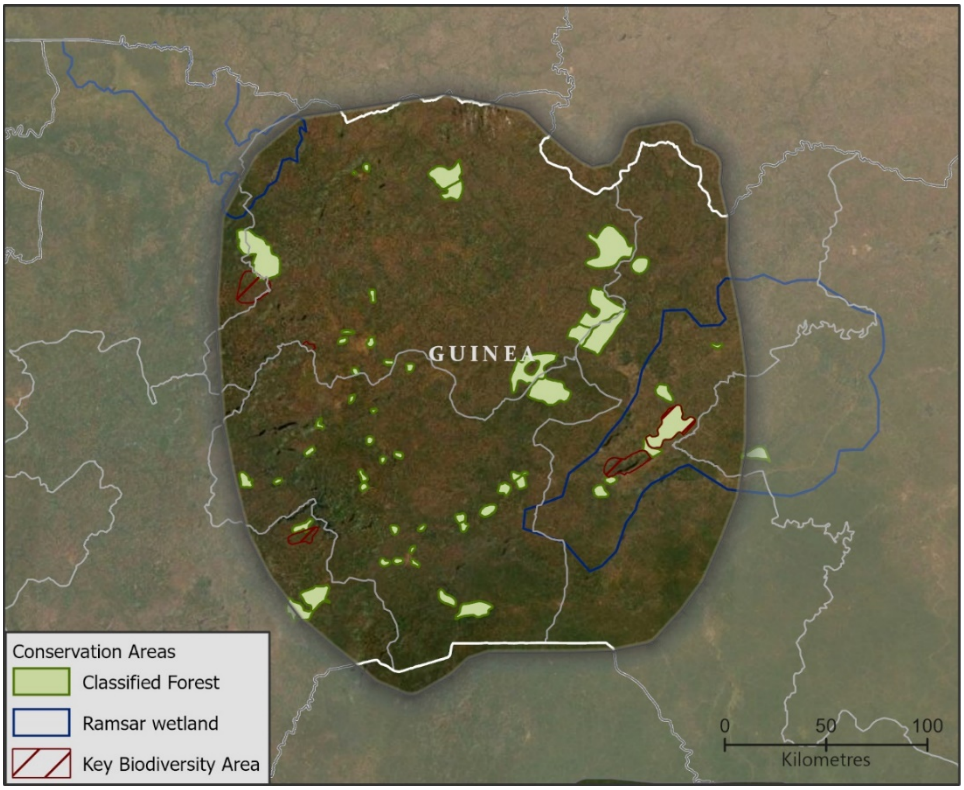

Figure 3 Protected areas and classified forests in Central Corridor Guinea

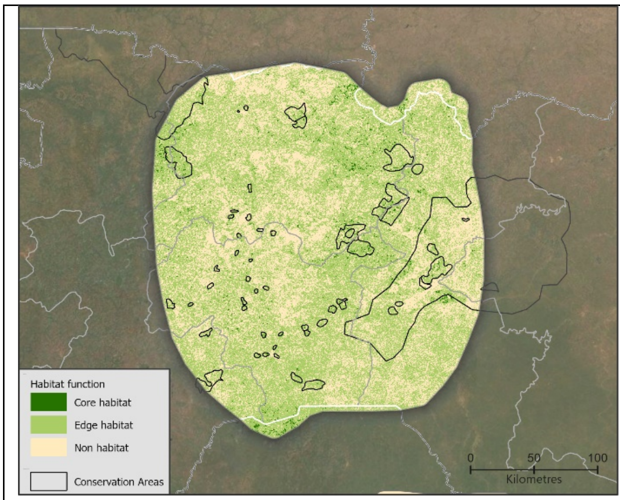

Figure 4 Extant forest cover in the focal landscape, with core habitat (dark green) and exposed edge habitat (light green). Most core habitat is in patches of habitat with exposed forest habitat, rather than larger connected habitat.

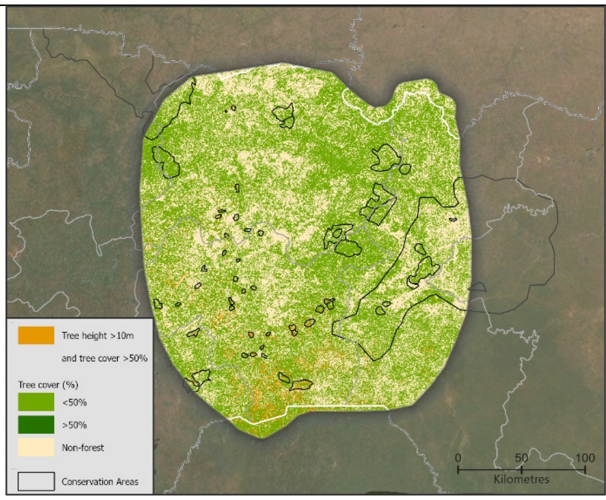

Figure 5 Representation of all forest habitat that is at least 50% canopy cover and of minimum 10 m tallest tree height (orange).

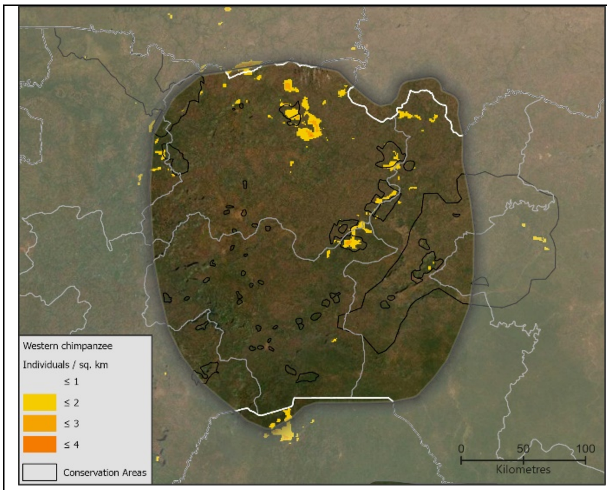

Figure 6 Using data from a variety of data from surveys and inventories, the assessment by Heinicke et al. (2019) identifies several areas where the modelled density of Western chimpanzee exceeds a predicted 3 individuals per km^2. Within the focal landscapes, areas of higher chimpanzee density include the Gambi and Kabela Classified Forests, Bakoun and Sobdry Classified Forests,Boula and Dokoro Classified Forests and the Bani and Darou-salam Classified Forests.

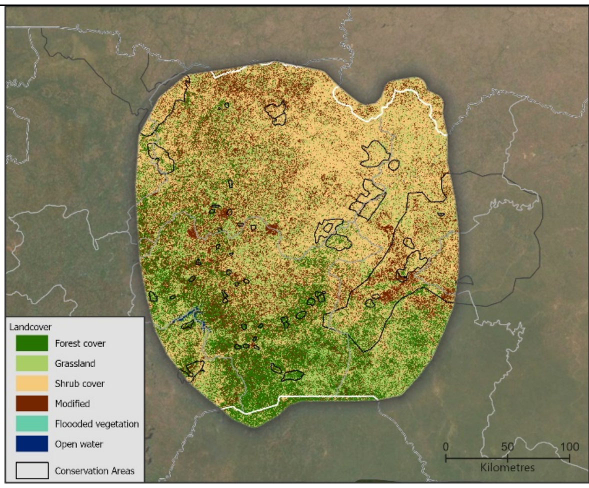

Figure 7 The overlap of protected areas and Landcover indicating habitats suitable to key species and connectivity between protected and classified forests

Classified as Globally Outstanding, the Western Guinean Lowland Forests ecoregion has been classified as part of the Upper-Guinea block of the Guineo-Congollian regional centre of endemism. High species richness and endemism are found here. Thirty-five endemic plants and 11 paleoendemics have been recorded in this landscape. Four mammals found in the ecoregion are either strict endemics or narrowly shared with the surrounding habitats. There is high diversity and endemism among herpetofauna of the ecoregion, and the reptile fauna includes three strictly endemic species (Brugiere & Kormos, 2009).

The Fouta Djallon is a mountainous region in central Guinea, covering an area of approximately 77,000 km^2 and averaging 900 m in elevation; the highest point in this region is Mount Loura at 1,538 m. The area is of great ecological importance due in part to being the headwaters of the river Gambia, as well as the Bafing, Koliba, Kolenté, Kaba, and Konkouré rivers.

The Fouta-Djallon freshwater ecoregion is classified as Bioregionally Outstanding; this ecoregion is characterized by isolated habitats with waterfalls and rapids, which have restricted the colonisation of species downstream and encouraged evolution of species that are unique to these rivers. Sixty fish species are described in the ecoregion, with one quarter of these being endemic species adapted to headwater streams. Nearly all endemic species are cyprinids (Lebbie & Burgess, 2004).

Sociocultural values / context

With a population largely dependent on natural resources and subsistence farming, there are high dependencies on ecosystem services. At the national and local levels, the region's forests provide a range of ecosystem services for the population of generally poor people. These services include supplying timber and other building materials, fuel for cooking, in the form of either firewood or charcoal, food (e.g. fruit, fungi, meat) as well as medicines (Norris & Fitter, 2011). Hunting traditions are strong and, for rural people in the hotspot, bushmeat provides a major source of protein for human consumption.

The region's forests also play essential roles in providing various hydrological functions, such as driving the water cycle itself, protecting water quality, regulating water flows, controlling soil salinity, controlling erosion and sediment deposition, and maintaining aquatic habitats (Ceperley N, Montagnini F, 2010; Leha, M.D.K; Matlocka, D.M., Cummings, E.C., 2013), which are essential to the persistence and well-being of local communities. Freshwater ecosystems provide immense benefits to local and national economies and provide the basis for the livelihoods of many of the poorest people within the hotspot (Smith, V. H. & Schindler, 2009). Benefits include flood regulation, where functioning wetlands buffer the rise and fall of floodwaters, provision and purification of water for drinking, and many direct benefits such as provision of building materials, nutrient rich floodplain pastures, medicines, and food such as from the inland fisheries. Traditional sacred groves, sometimes called "fetish groves" are important to local communities within the hotspot.

The region's forests contain high amounts of biomass carbon, which contributes to mediating climate change processes (regulating service) and maintaining biodiversity (supporting service) at the global scale. These forests play an important role in the global climate balance, by emitting or sequestering significant amounts of carbon dioxide, depending on their condition and degree of deforestation or degradation.

Threats and pressures to biodiversity and ecosystem services in the landscape

STEP 2
Assessing and understanding landscape: threats and pressures today and in future

STEP 1 | STEP 2 | STEP 3 | STEP 4

Key threats arise from land use change resulting in a suite of direct impacts derived from different activities and indirect and induced and cumulative impacts derived from these within the landscape.

Within the Central Corridor, Mamou lies at the centre with the railway line from Conakry to Kankan. All vehicles going to the Fouta Dallon, the forest region or Haute Guinée have to travel through Mamou, thus drawing people to the region enabling transport of goods and services, including potential wildlife and forest products, invasive species and disease. The Central Corridor is ear-marked for rapid and expansive development, following the key infrastructure corridors between Conakry and Mamou, and then north to Labé, Tougué and east towards Labola and onward to Simandou. The regional land use allocations for forestry, mineral extraction and exploration are shown in Figures 9 - 14 below. Its main industry used to be meat processing until the 1990s, while it also acts as an important transport hub. New rail and road connections will be made, with upgrades to existing routes ensuring faster and more effective access to markets and distribution networks. Following these access routes will be power and water supplies and the development of commercial agriculture. The Ministry of Mines is actively promoting the development of a multi-use landscape for mining, infrastructure, and agriculture in the Central Corridor, centred on Mamou.

The population of the region is growing rapidly, with key densities in Labé and Pita regions as shown in Figure 8.

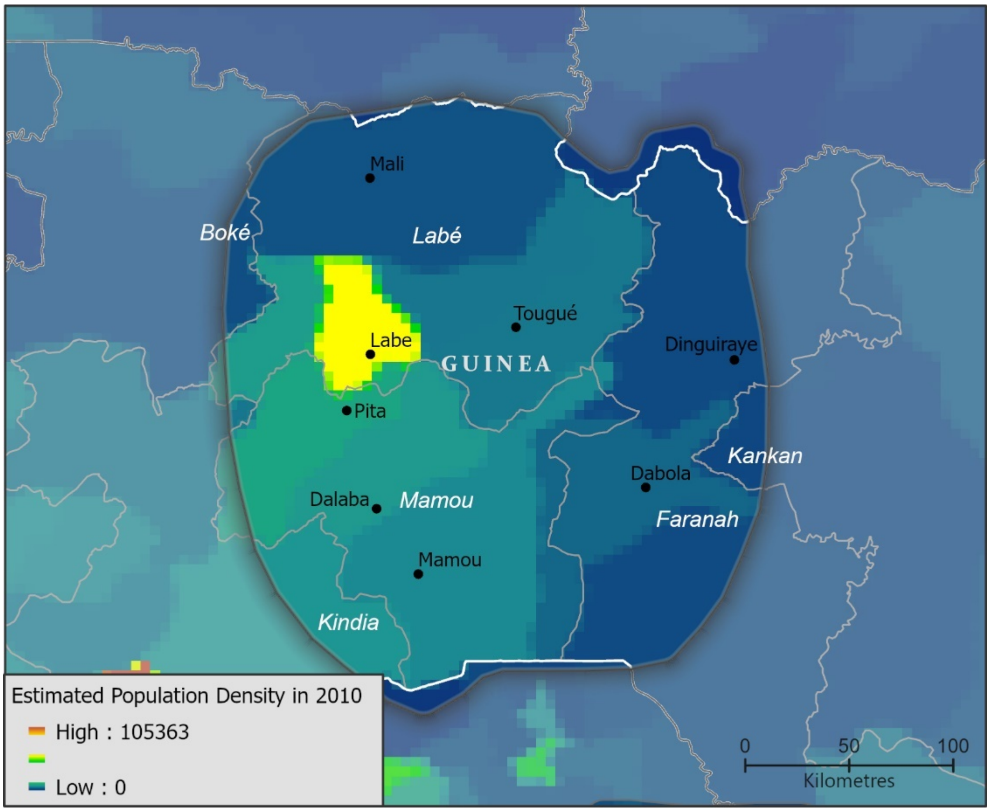

Figure 8 Estimated population density in the Central Corridor, Guinea.

Agriculture and forestry

Landuses across the Central Corridor are dominated by natural habitat with patchy subsistent agriculture and human settlement. The principal subsistence crops (with estimated 2009 production) are manioc, rice, sweet potatoes, yams, and corn. Cash crops are peanuts, palm kernels, bananas, pineapples, coffee, coconuts, sugarcane, and citrus fruits (Nations Encyclopedia, 2021)

The early inhabitants of the Fouta Djallon established the agricultural production systems in the area, including the breeding of the indigenous and tsetse resistant Ndama cattle breeds. The breeding of Ndama cattle continue to be central to the region's economy to this day, undertaken primarily by Fulani pastoralists (Baker et al., 2013). The area is also known for its hillside and largely rain-fed potato, citrus and rice production.

Pastoralism poses a threat to biodiversity in the area, due to uncontrolled burns to refresh grazing lands, and trampling and overgrazing of communal, classified and protected (Couch et al., 2019). Additionally, the mountainous topography of the area means that soil erosion is a common threat resulting from overgrazing and traditional hillside production methods for staple crops. In 2017 there were 233 villages and approximately 67,000 people living and farming within the proposed borders of the Moyen-Bafing National Park, encompassing six classified forests) (Couch et al., 2019).

ImpactAgri, a progressive agricultural commodities development company, is planning to develop community-based cooperative agriculture projects for cash crops in the infrastructure corridors between Conakry and Mamou, and beyond towards Labé, Tabola and Tougué. The farms will be developed within 20-50 km radius of infrastructure and proposed mines, ensuring generation of employment and reduction of induced impacts. *What general trends can we see in smallholder growth over time?*

The central Guinea focal landscape comprised a population estimate of 2,670,567 people per the 2014 national census. Adjusting for 2020, with a national population growth rate of 2.8% per annum, the population of the landscape today is estimated at about 3,151,825 people. Of these 3+ million, it is estimated that 2,206,277 (70%) are farmers in 2020, with an average farm size of 2 ha[1].

If population growth in the region were to continue apace at approximately 2.8% per annum, the ratio of farmers in the region were to hold at approximately 70%, and we assumed for a moment no further land conversion, by 2030 there would be 25% less agricultural land available per farmer (from 2 ha per farmer to 1.52 ha per farmer), and by 2050 this land would be more than halved (-56.3%) to 0.87 ha per farmer. We can use this information to consider incentives that are likely to exist for land conversion in this landscape in the future.

The total land area of the Central Guinea focal landscape is approximately 75,524 km^2, and with 59% of land being classed as agricultural in the last census (2014), we can estimate that about 44,567 km^2 are farmlands. A 25% reduction in farmland availability per person between 2020 and 2030 (from 2 ha per person to 1.52 ha per person) implies a potential incentive to convert the same amount of land to agriculture, which would entail conversion of an additional 17,364 km^2, bringing the total agricultural land in the landscape from 59% to 77%. According the World Bank Report on Forest Smart Mining, induced impacts from smallholder ingression related to mining projects and infrastructure results in significant land use change. The growth of the mining sector in this region is likely to exacerbate this estimate unless land use planning and alternative livelihoods are instituted.

A number of forestry concessions lie within the landscape; however, the sector is poorly developed and does not present an immediate threat.

Figure 9 Forestry concessions Central Corridor

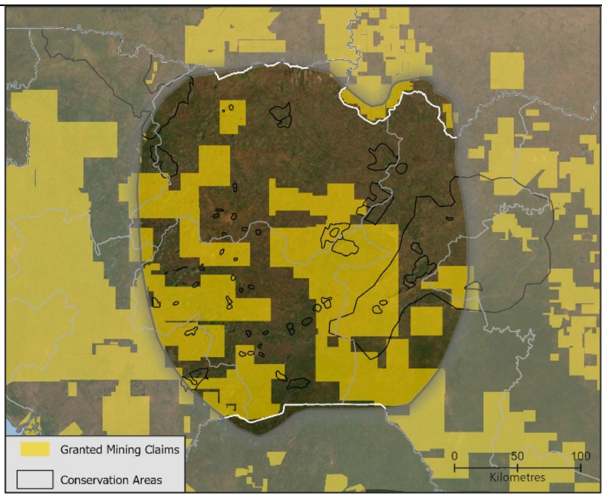

Figure 10 Valid extraction and exploration licenses Central Corridor and showing different industrial and infrastructure land use allocation. Vast swathes of the landscape are covered by exploration licenses for potential mineral exploitation development

[1] Data sourced from the World Bank's Open Data platform: https://data.worldbank.org/, and from the Food and Agriculture Organization of the United Nations' FAOSTAT: http://www.fao.org/faostat/en/#data/RL/visualize

Extractives and infrastructure

The impacts of mining and hydroelectric power projects loom in Central Corridor. These include proposals in and adjacent to the Moyen-Bafing National Park area; the cohabitation between Moyen-Bafing National Park and the Koukoutamba dam; threatening large-scale conversion and loss of habitat and disruption to local communities. None of the mines is yet in operation, nevertheless development is increasing rapidly and permits to mine have been granted for the Toubal and Somalu Projects.

Mining

Somalu Bauxite Project

This is the largest Anglo African Minerals (AAM) bauxite project and is located some 140 km north-east of the Debele rail spur. An estimated inferred resource of over 400 Mt, grading over 42% alumina and 1% silica. An Environmental and Social Impact Notice was awarded in January 2016. AAM applied for a concession at the end of 2017, and signed a mining convention in 2018 with a 2019/20 production target of 5 Million tonnes per annum (Mtpa). Subject to completion of new port facilities at Conakry, target production is set at 10 Mtpa from Q2 2020. AAM has also discussed developing Somalu with the Chinese Consortium group. The company currently has 100% ownership of this licence.

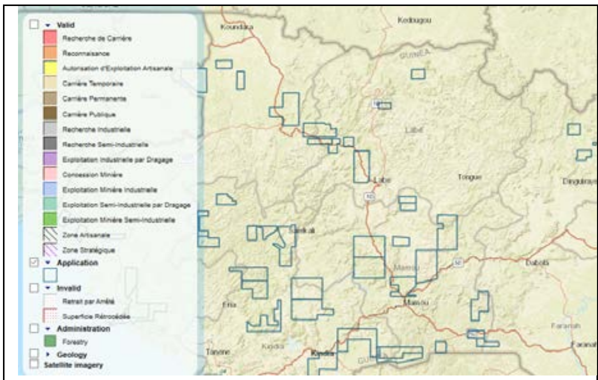

Figure 11 Current applications, mostly bauxite and cobalt/nickel, Central corridor

Figure 12 Location of Toubal and Somalu Bauxite Projects, Central Corridor

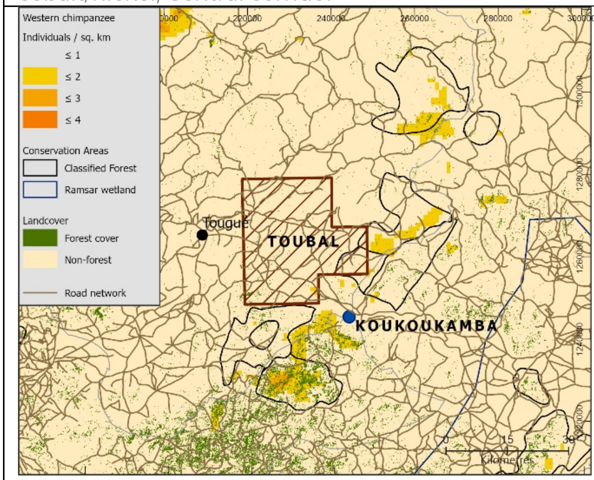

Figure 13 Toubal Project, Anglo African Minerals bauxite project in the vicinity of the Moyen-Bafing National Park

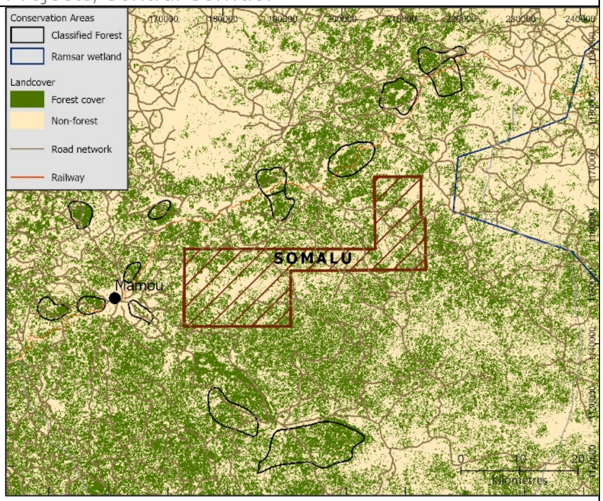

Figure 14 Somalu Project near Mamou, Central Corridor, Guinea

Toubal Bauxite Project

This 750 km[2] licence is located in northern Guinea near Tougué. It has been extensively explored, including over 35,000m of drilling and has an inferred resource of some 722 Mt, grading 42.6% alumina and 3.2% silica, was estimated in 2015. An Environmental and Social Impact Notice was awarded in January 2016 and a further drilling campaign is planned for Q1 2017. AAM currently has a 92% interest in this licence. This project overlaps with the Moyen-Bafing National Park.

MINTEP Project

This licence is located in northern Guinea close to the Toubal Licence. It is suggested that the licence may host up to 750 Mt high grade bauxite comprising 44% alumina and 3-5% silica. An exploration programme is planned.

Infrastructure

In February 2016, the Central Corridor Development Project was signed by the Guinea Government and the China Rail Engineering Group. AAM is to undertake a feasibility study to develop export infrastructure to access its other licences through the Central Corridor Development Project, which may also provide hydro-electric, alumina, refining, and agriculture projects. This is now a non-binding MOU specifically to develop an infrastructure solution for the Central Corridor Development Project which would unlock an infrastructure solution which could access the Southern Corridor to Simandou.

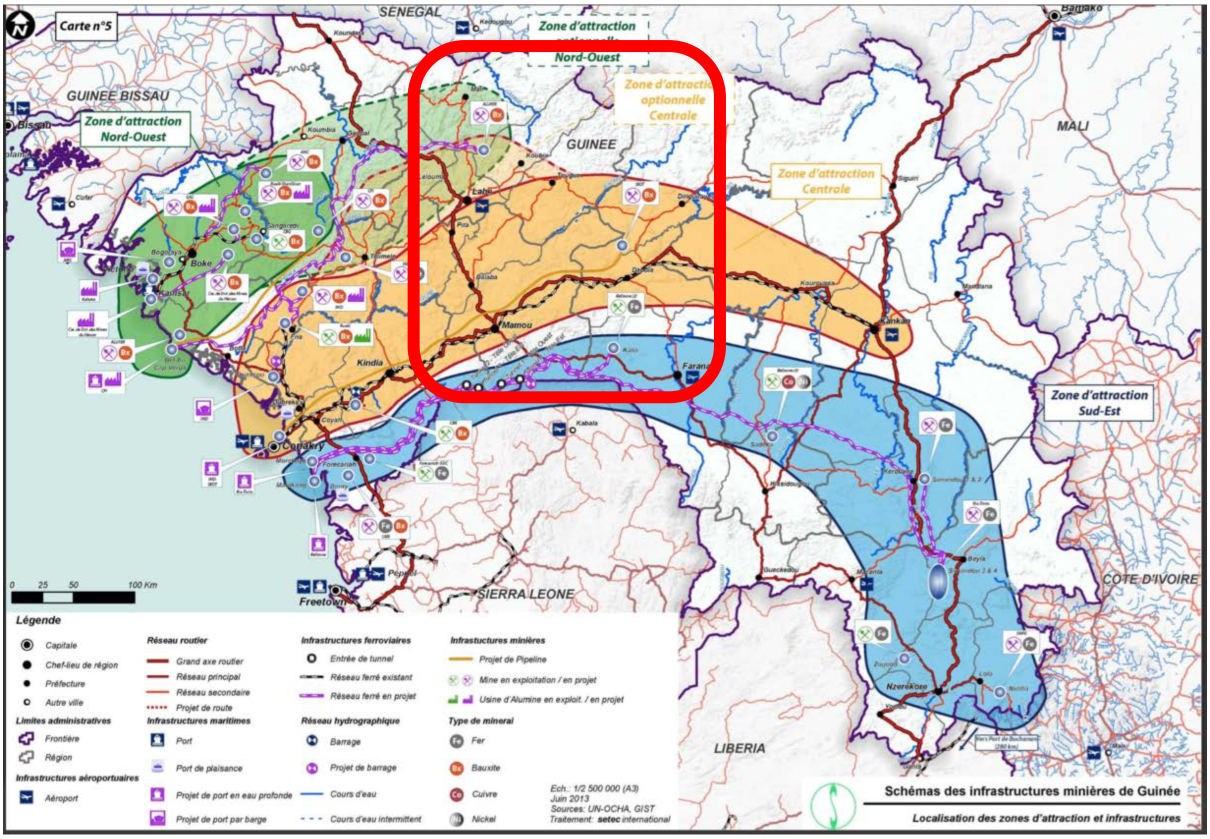

Figure 15 Infrastructure development corridors in Republic of Guinea. Orange depicts the area overlapping with the Central Corridor landscape, with port and rail facilities linking mining, agriculture and hydropower projects (Republic of Guinea Ministry of Mines and Geology, 2021).

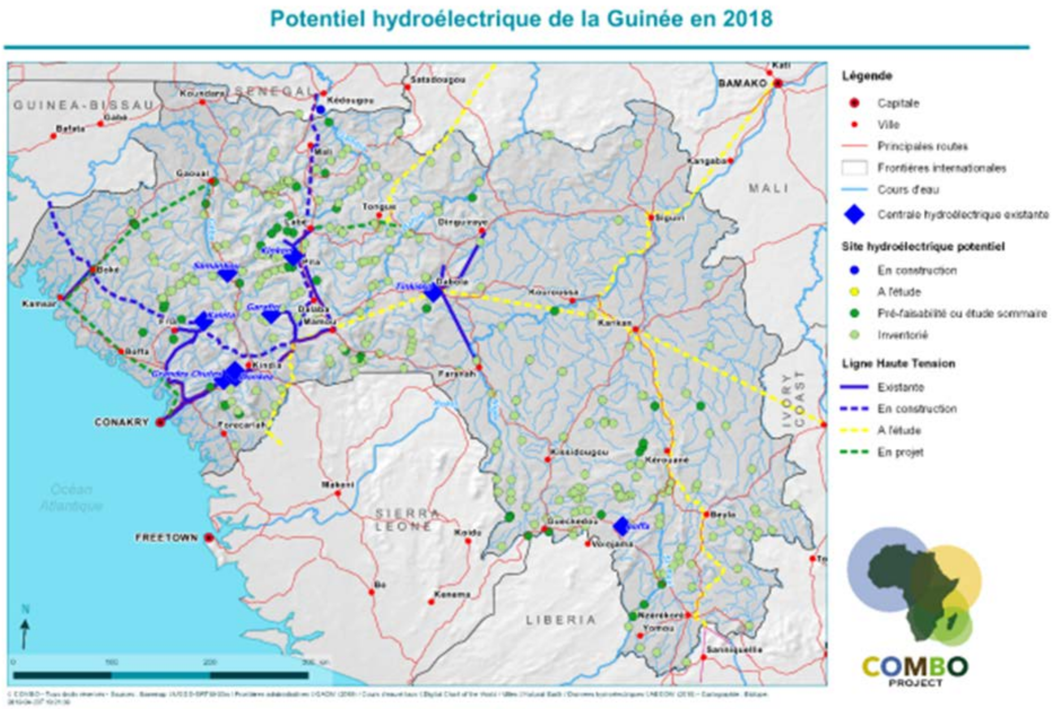

Figure 16 Areas of high natural potential and feasibility for hydropower development in Guinea (AECOM 2018)

Hydropower

Within the Central Corridor the Tinkisso Hydropower (HPP) project is active, with associated powerlines running servitudes across the landscape. Two regional HPP are under development in the Central Corridor: the Sambangalou (128 Megawatt (MW)) regional HPP, being developed by the Gambia River Organization for Development on the Gambia River (bordering Senegal and Guinea), and the Koukoutamba (294 MW) HPP, being developed by the OMVS on the Senegal River. Other projects that are being considered by the Guinean authorities include Amaria (300 MW), Korafindi (100 MW), and Kogbedou-Frankonedou (90 MW).

Guinea is also exploring, with support from IFC Advisory Services, the development by private investors of solar photovoltaic projects (Republic of Guinea Ministry of Mines and Geology, 2021).

The infrastructure of the Koukoutamba hydroelectric project will be built in the Bafing River Valley, about 7.5 km upstream of its confluence. All the infrastructure will produce 294 MW. Thanks to two 225 kV high-voltage lines, this energy will be transmitted over 600 km between Guinea and Senegal, i.e. following the route set by OMVS, namely: Linsan-Labé Mali-Sambangalou-Kédougou-Tambakounda-Kaolack. To facilitate access to the site, a 150 km paved road should also be built.

Koukoutamba is a tributary of the Senegal River despite the presence of the national park of the Moyen-Bafing, located not far from there, which is one of the last remaining protective areas for western chimpanzees (Takouleu, 2019).

A new 225 kV powerline is planned between Forni and Linsan, running through Mamou (World Bank Group, 2018).

Other pressures / threats (if known)

The exploitation of Guinea's natural resources generates diverse pressures on the environment (International Monetary Fund, 2017) caused by illegal harvesting, unsustainable modes of production, and the release of pollutants. These threats are present within the Central Corridor as in other areas. Water resources are threatened, resulting in reduced flow rates, silting of riverbeds, water pollution, and more. Forest resources are dwindling to the detriment of plant cover and biodiversity. These pressures, attributable mainly to human activities important to survival or social, economic, and cultural development are accentuated in Guinea by climate factors manifested increasingly through (i) more frequent meteorological events (flooding, drought, and heat waves, especially in Upper Guinea); (ii) health risks relating to the transmission of animal diseases potentially harmful to humans; and (iii) population displacements.

The major threat to this ecoregion is traditional slash and burn agriculture, which has led to loss of the majority of the forest cover, affecting freshwater systems (e.g. through erosion and sedimentation).

The Global Human Modification Gradient (Garrigue et al., 2015; Kennedy, Christina M., Oakleaf, James M., Theobald, David.M., Baruch-Mordo, Sharon., Kiesecker, 2019). provides a cumulative measure of human modification of terrestrial lands for the year 2016. The index for the Guinea focal landscape is shown in Figure 17 below. Darker colours in the image demonstrate the association of human impact on natural habitat with infrastructure corridors and urban settlement, however there are diffuse habitat degradation impacts visible across the landscape from deforestation and conversion of land to agriculture. This is set to increase rapidly with the development of agribusiness and extractive sectors as described above.

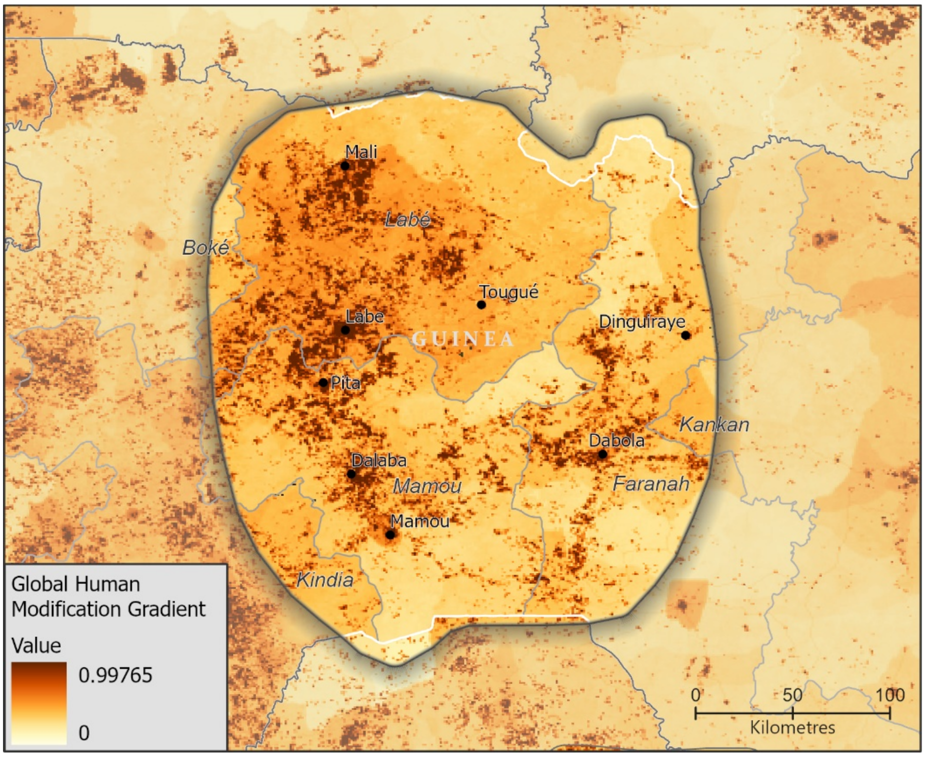

Figure 17 Global Human Modification Gradient (Kennedy, Christina M., Oakleaf, James M., Theobald, David.M., Baruch-Mordo, Sharon., Kiesecker, 2019) represents the level of human influence on biomes (dark colours high influence, lighter colours low influence).

Assess impacts of multi-sectoral development

STEP 3
Impact assessment and mitigation planning

STEP 1 | STEP 2 | STEP 3 | STEP 4

A systematic assessment of the impacts of each of the active sectors (agriculture, mining, infrastructure, hydropower) as well as the likely induced impacts of urban and rural development through the in-migration of people to the area was undertaken. The key impacts to biodiversity and ecosystem receptors are summarised according to sector in Table 2.

Table 2 The key impacts to biodiversity and ecosystem receptors are summarised according to sectors

IMPACT CLASS	AGRICULTURE	MINING	INFRASTRUCTURE	HYDROPOWER	URBAN SETTLEMENT	RURAL SETTLEMENT
Clearance of natural habitat	x	x	x	x	x	x
Species loss through mortality and habitat loss	x	x	x	x	x	x
Degradation of natural habitat	x	x	x	x	x	x
Fragmentation of natural habitat	x	x	x	x	x	
Soil compaction	x	x			x	
Clearance of mature plantation	x	x	x		x	
Noise pollution from operations	x	x	x		x	x
Light pollution from operations		x	x			
Operation induced injury/mortality	x	x	x	x		
Dust pollution from operational activities	x	x	x			
Human-wildlife conflict	x	x	x	x	x	x
Pollution of water resources	x	x			x	
Restricted access to water resources	x	x			x	x
Visual barriers		x	x		x	
Introduction and spread of alien and invasive species	x	x	x	x	x	x
Exposure to disease	x	x	x	x	x	x
Fire events	x	x	x		x	x
Reduction in soil productivity and quality	x				x	x
Altered drainage networks	x	x	x	x	x	
Air emissions	x	x	x		x	

The greatest threat to species and habitats, particularly those requiring intact or connected forest, is loss of habitat and fragmentation at a landscape scale, with particular threats coming from cumulative impacts of multiple operators and multiple activities as indicated above. Similarly, the introduction of alien and invasive species and exposure to disease, of high importance as humans becomes vectors for disease to chimpanzees, and zoonotic exposures transversely where wildlife transfer disease to humans (e.g. Ebola, SARS, Covid-19). Human wildlife conflict and the resultant threats encompassing poaching and wildlife trafficking also increase cumulatively as the landscape fills with multiple activities.

The Framework is underpinned by four primary, linked, objectives needed to achieve sustainable development outcomes in complex multi-use landscapes. The landscape objective provides the spatial scale needed for the delivery of social, biodiversity and ecosystem services and climate objectives – all of which are dependent on applying the mitigation hierarchy to address impacts of development, using a socioecological framework. Success for each of these objectives relies on managing the impacts of projects at both a local (direct, indirect and induced impacts) and landscape scale (cumulative and induced impacts). Using the socioecological framework enables consideration of the complexity in the landscape with respect to trade-offs, risks to biodiversity and ecosystem services and society where objectives fail, and the identification of positive opportunities available through collaboration across and between sectors in the landscape. Through careful, collaborative application of the mitigation hierarchy and consequent management of the issues and threats in the landscape, social, climate and ecological objectives are more likely achieved. For example, reduced deforestation and degradation, habitat restoration and protection, increase in resilience of ecosystems and success of nature-based climate solutions, continued or restored ecosystem services.

Application of the mitigation hierarchy

STEP 4
Applying the mitigation hierarchy across a landscape

STEP 1 | STEP 2 | STEP 3 | **STEP 4**

In the context of national policies and commitments and international agreements, Guinea has positioned itself to engage with and deliver on signficant climate, forest and biodiversity objectives. The Government has set up an appropriate monitoring and evaluation system drawing lessons from the conduct of previous development programs. Guinea is part of the dynamics of statebuilding and peacebuilding as a fragile country and in its National Voluntary Report 2018 considers the questions of resilience and sustainability of resources, ecosystems and lifestyles as priorities.

Guinea will rely on public-private and south-south partnerships and on innovative financing for the implementation of the Sustainable Development Goals. For example, two million hectares have been committed under the Bonn Challenge (which brings together existing international commitments, including Aichi Target 15, United Nations Framework Convention on Climate Change Reducing Emissions from Deforestation and Degradation (REDD+) goal and RIo +20 United Nations convention to Combat Desertification (UNCCD) Land Degradation Neutrality (LDN) goal). This is an implementation vehicle for national priorities such as water and food security and rural development while contributing to the achievement of international climate change, biodiversity and land degradation commitments.

Under the LDN Target Setting Programme of the UNCCD, Guinea has already set national voluntary LDN targets, established an LDN baseline, and formulated associated measures to achieve LDN. The LDN targets provide Guinea with a strong vehicle for fostering coherence of policies and actions by aligning the national LDN targets with measures from the Nationally Determined Contributions. In the context of climate change and biodiversity loss, Guinea will strive to restore 375,000 ha, i.e. 55% of the total area of degraded lands, and limit to 1% (238,440 ha) the loss of non-degraded land relative to the 2000-2010 reference period. Prority areas in Central Guinea include the Niger watershed, Senegal watershed and Gambia watershed.

Under the Convention on Biological Diversity, Guinea is committed to increasing its protected areas network to 25% by 2025. This provides significant incentive and a target for protection of the unique biodiversity of the Central Corridor. On the other hand, Guinea is lagging in terms of climate commitments and whilst a signatory of the Paris Agreement, has no formal REDD+ action plan as part of its Nationally Determined Contributions. Clearly there are opportunities through forest protection and restoration to develop carbon offsets and credits for both voluntary and compliance markets.

Interministerial cooperation is fundamental, particularly between powerful ministries such at Mining & Energy and Finance with those responsible for Environment, Agriculture, Development, Forestry and Rural Affairs. Strategic cooperation is needed to deliver sustainable outcomes through land use planning and Climate Change mitigation alongside development. Site level consideration of impacts and mitigation measures by each mining company and agricultural development project must be dealt with in the ecological context whilst taking into consideration the side implications and sustainability in the landscape. The cumulative impacts of infrastructure development and land use change, for example, will likely undermine the integrity of the ecosystem. Therefore cooperative management and mitigation of these actions by each actor is necessary.

Figure 18 Impact and mitigation planning therefore needs to inform the regulator what is needed enable successful application of the mitigation hierarchy and optimise sustainable development, including through enabling policy, stakeholder engagement and compliance enforcement.

Recommendations

Anglo African Minerals and ImpactAgri need to contextualise their projects in the landscape, taking into account direct and indirect impacts as the footprint of the project, and how these contribute to additive or cumulative impacts in the landscape. They need to have a vision beyond the fence, also asking how induced impacts from the project and other actors in the landscape impact the integrity and sustainability of the broader socioecological context. In applying the mitigation hierarchy from the site level, the impacts of each project can be contained as far as possible, nested within the potential impacts of the project to contribute to unacceptable or unsustainable outcomes for ecosystems across the landscape. When designing the mitigation planning, each project needs to consider the implications of each step in the mitigation hierarchy in the landscape context, taking into account those impacts and mitigation hierarchy actions of other actors in the landscape, and how the project can contribute to the overarching sustainable development objective (biodiversity protection, restoration and integrity etc.). The actors are forced to identify and acknowledge their part in impacting (or undermining) the integrity of the socioecological context and then to address the complexity generated through both site and landscape level mitigation interventions. This will include avoiding highly value species and habitats such at those identified above, minimising impacts through e.g. efficiencies and rationalisation of infrastructure with neighbours, implementing restoration and enhancement measures both on site and through collaborations with other agencies. Stakeholder collaboration and partnerships, with civil society and authorities, is fundamental and the Framework encourages all parties to contribute to the identification and delivery of landscape objectives.

This Framework therefore addresses potential cumulative impacts in the landscape, to pre-empt and direct development design, siting, timing, scale and scope where impacts would otherwise result in unacceptable outcomes for ecosystems such as deforestation, degradation, fragmentation, loss of species and loss of ecosystem services. The Framework enables a holistic and multi-sectoral approach to development and ensures the integrity and persistence of ecosystems in the landscape is a central objective underpinning sustainable development.

Responses through the application of mitigation and management measures through the mitigation hierarchy are necessary to avoid, minimise and ecological restore impacts at both a site and landscape scale. These need to be undertaken collectively and simultaneously by all actors, throughout the planning, development and operational life cycles of each development. In many cases, collaboration with cross-sectoral peers in the landscape will achieve positive outcomes to maintain intactness, connectivity, species resilience and persistence in the ecosystem and the functional integrity and sustainability of ecosystem services.

The most important stage is the identification of areas to avoid, in this case all protected forest and other habitat should be retained in addition to key areas linking these areas to enable movement and migration of key species and ensure their sociecological viability. In all cases, footprints of projects and operations should be minimised and infrastructure optimised to reduce impacts. This requires land use planning that takes into consideration the socioecological context as described above, to define optimal areas and scale for agricultural development, as well as pathways for infrastructure. Cooperation between land users and sectors is necessary to identify common infrastructure corridors that will e.g. avoid fragmentation and loss of habitat.

Somalu Mine Landscape

Anglo Africa Minerals is developing collaborative landscape enterprise opportunities with ImpactAgri. Located on the edge of Mamou, it is clear that the project Somalu is part of a rapidly changing development landscape, with a growing population, many of which are attracted to the area as a market town, infrastructure hub and corridor, and a centre of more diversified economic development.

All development needs to avoid impacts to critical forest areas of Gueroua, Bagata, Beauvois, Bellel Gouba, Bantarawel to the north and west, and Konkoure, Fetto and Koni in the south and east. Restoration of corridors between these forest blocks is important to maintain connectivity for chimpanzees and other key species. Figure 19 shows the forest cover, classified forests and protected areas and the overlap of these with the mine concession. Care needs to be taken to ensure no forest loss along the infrastructure corridors and that development takes into consideration the need to maintain connectivity between forest patches and protected areas. Fuure development of infrastrucure should follow routes of low conservation value or where landcover alteration is already prevalent.

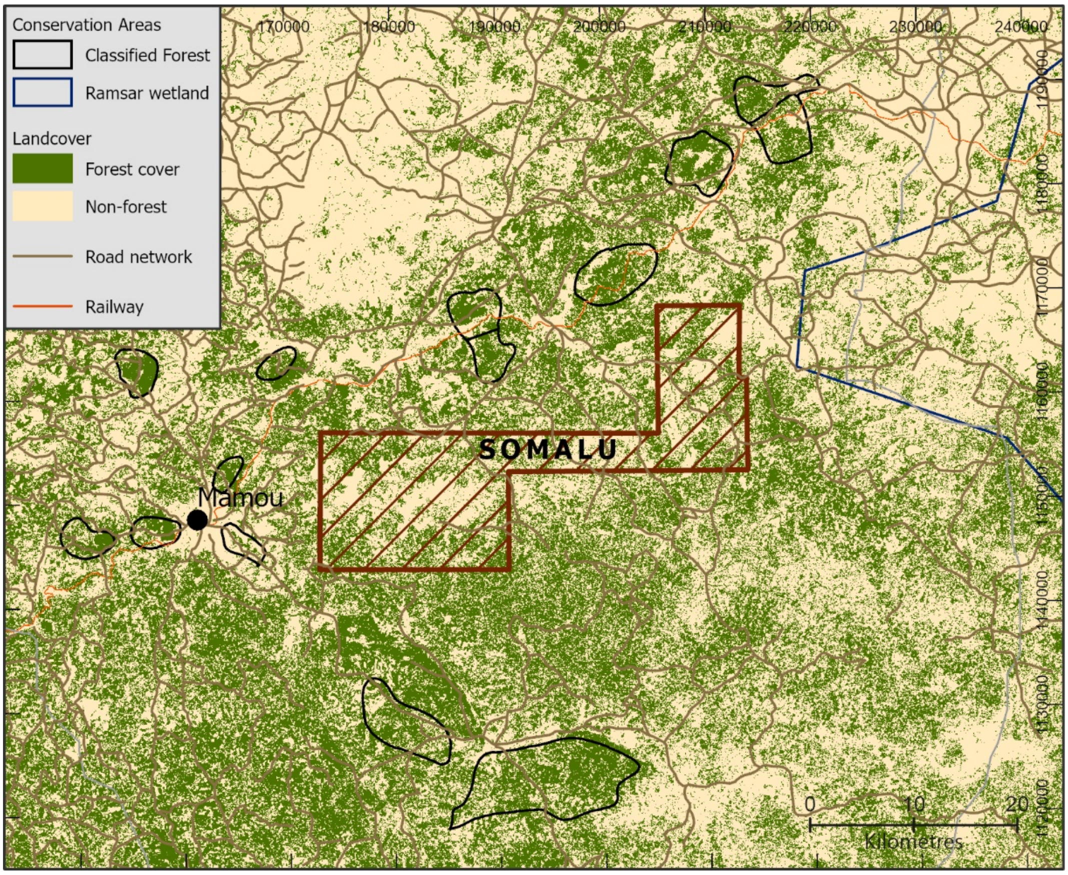

Figure 19 The Somalu mine landscape close to Mamou and the Central Corridor key infrastructure corridor. Natural habitat and forest cover between classified forest provides opportunities in the landscape to maintain connectivity between protected areas.

Toubal Mine Landscape

Located near Tougué, the proposed Toubal Mining Project lies within the watershed of the Koukoutamba hydroelectric dam project and overlaps with the Moyen-Bafing National Park, a new protected area that forms the biodiversity offset for chimpanzee impacts of the bauxite province of Boke Region. Furthermore, the area comprises critical Western chimpanzee habitat and overlaps classifed forest.

Figure 20 and Figure 21 provide the context for the Toubal mine, showing the occurrence of western chimpanzee populations across the landscape, some of which lies within the mining concession. Note that there is overlaps between the protected area and the mine concession – demonstrating keys areas which need to be avoided if the mine is to be developed. Corridors of forest and riverine habitat need to be maintained in the landscape. Furthermore, Figure 21 illustrates the added and cumulative land use activities and pressures to the landscape from hydropower development, additional mining leases and infrastructure. Maintaining corridors for connectivity and landscape intactness is fundamental to maintain both the watersheds, western chimpanzee habitat and ecosystem values.

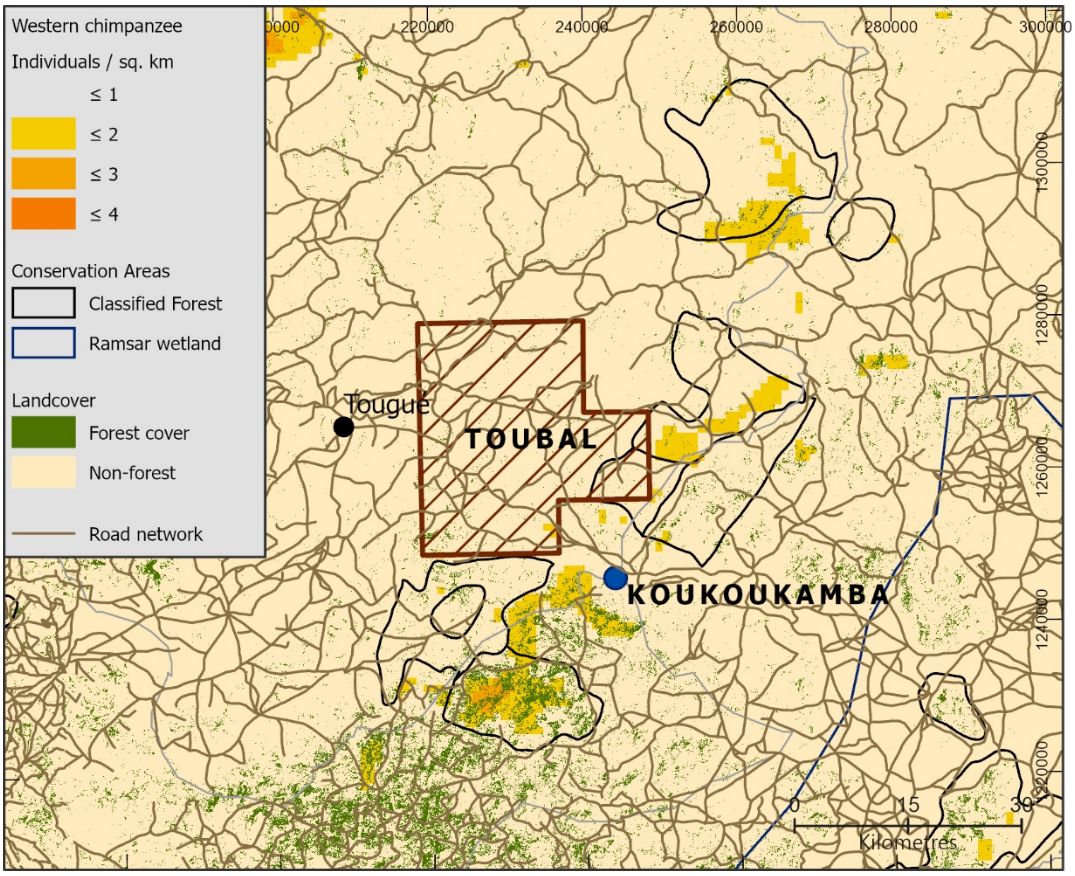

Figure 20 Toubal mining concession, chimpanzee densities, the Moyen Bafing National Park and classified forests

The Government of Guinea should establish strict protection of the Moyen-Bafing National Park, preventing development within the boundaries and buffer areas. Working with local authorities and traditional leaders, alignment of objectives and understanding the impacts of these mega projects requires AAM to engage with Omvs and Sinohydro, the key stakeholders driving the Koukoutambo Project. The Toubal Project presents high threat to the socioecological integrity of this landscape. Any future development must avoid the Moyen-Bafing National Park and intact forest areas within the concession, protecting forest corridors, riparian habitats and high value biodiversity in the planning and design, and must contribute to the restoration and protection of degraded habitat.

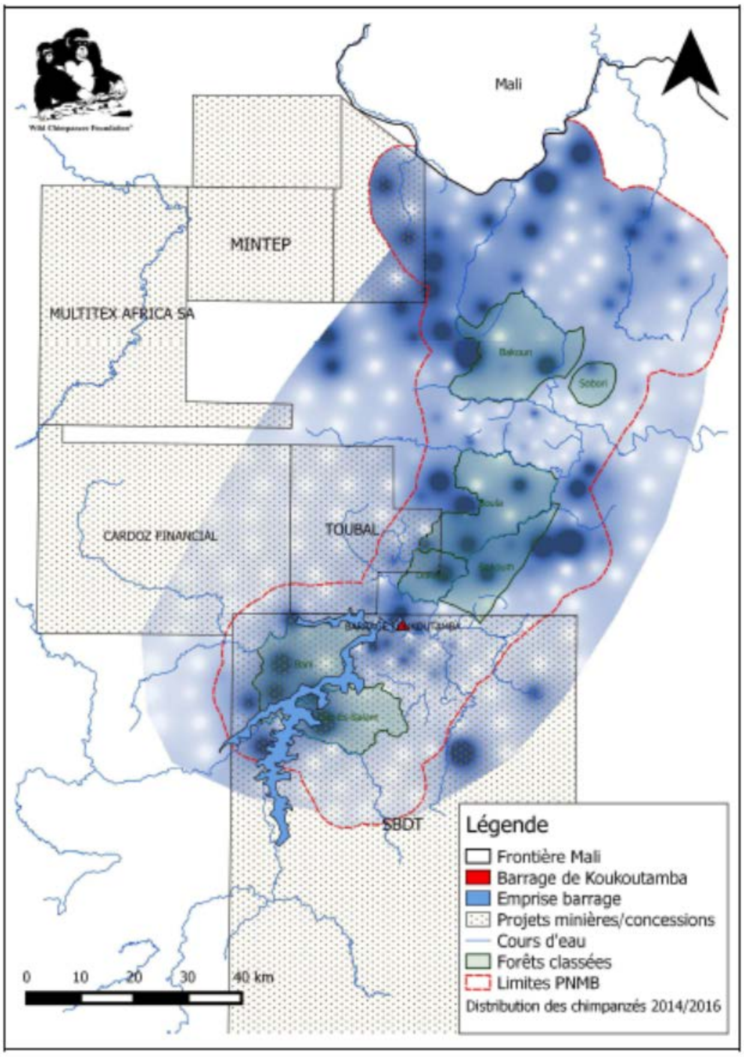

Figure 21 The Toubal bauxite mining, hydroelectric power, and classified forest landscape

The highest level of environmental and social management standards need to be applied to ensure water contamination, air pollution, soil degradation, noise and other impacts are avoided and minimised. The acknowledgement and management of in-migration, causing induced and indirect impacts associated with rural development and land use change, which are anticipated to be a considerable threat in this landscape, is fundamental to avoid encroachment into key habitat necessary to maintain ecosystem services and species persistence.

Stakeholder engagement

Key stakeholders must be consulted throughout the planning, development and implementation process. It is necessary to ensure inclusivity, due consultation and process, to ensure all impacts are avoided and mitigated, and opportunities for the most sustainable outcomes identified. As outlined above, key stakeholders for the Mamou/Somalu landscape include:

- Ministry of Mines
- Ministry of Environment and Forestry (Protected Areas Authorities, CEGENS)
- Sub-national authorities of Mamou and Dalaba
- Anglo African Minerals

    - Chief Executive Officer and Project Professional
- ImpactAgri
    - Chief Executive Officer and Project Executives
- Local Communities near the mines
    - Community and traditional authorities

The stakeholders in the Toubal Mineral landscape are:

- Ministry of Mines
- Minister of Energy and Hydraulics of the Republic of Guinea
- OMVS, Council of Ministers
- Ministry of Environment and Forestry (Protected Areas Authorities, CEGENS)
- Sub-national authorities of Pita, Labé, and Tougué
- Anglo African Minerals
    - Chief Executive Officer and Project Professional
- ImpactAgri
    - Chief Executive Officer and Project Executives
- OMVS and Sinohydro
    - Koukoutambo Hydropower project
- Local Communities near the mines
    - Community and traditional authorities

These stakeholders will be revisited throughout the application of the Framework and updated and adapted with local and contextual knowledge.

Table 3 provides mitigation options for primary impacts anticipated from mining, agriculture, hydropower and rural development in the Central Corridor.

Table 3 Mitigation options for primary impacts anticipated from mining, agriculture, hydropower and rural development in the Central Corridor

IMPACT CLASS	MITIGATION HIERARCHY STEP	MITIGATION ACTION
Clearance of natural habitat and loss of species through mortality and loss of habitat	Avoidance	• Alternatives - Engineering solutions, operation plans, infrastructure planning, footprint design • Forego/sterilise resource • Avoid clearance of areas with high densities of fruiting trees • Leave (reserve) trees or groups of trees in the harvest concession for regeneration purposes, and to provide nesting sites, food sources, cover, and travel corridors
	Minimisation	• Establish buffer areas between areas cleared for project activities • Minimise the number of access and extraction roads • Appropriate timing and amount of natural habitat clearance • Sustainable harvesting practices that reduce collateral damage • Allow canopy closure over roads and other linear clearings
	Restoration	• Restoration of natural habitat post-impact • Reforestation to establish corridor function and improve connectivity between habitat patches (e.g. riverine areas known to support chimpanzee movement) • Early and progressive closure and rehabilitation of utilised land including revegetation and reforestation
Degradation of natural habitat	Avoid	• Alternatives- Engineering solutions, operation plans, infrastructure planning, footprint design • Forego/sterilise resource • Avoid clearance of areas with high densities of fruiting trees • Leave (reserve) trees or groups of trees in the harvest concession for regeneration purposes, and to provide nesting sites, food sources, cover, and travel corridors
	Minimise	• Minimise the number of access and extraction roads in and adjacent to high condition and core habitat and prioritise use of existing routes and already degraded land (e.g. reusing old logging and similar road networks instead of opening up new ones) as long as such “recycling” does not lead to increased damage to forest canopy (Morgan & Sanz, 2007) • Leave (reserve) trees or groups of trees in the harvest concession for regeneration purposes, and provide nesting sites, food sources, cover, and travel corridors

		• Establish buffer areas between areas cleared for project activities and high condition or core habitat to minimise the effects of encroachment on avoided habitat • Ensure that tree stems removed are temporally and spatially staggered • Allow canopy closure over roads and other linear clearings to maintain habitat connectivity • Natural vegetation in the forest management area should be managed to ensure a variety of successional stages • Diversity in plantation stands should be promoted (e.g. multi-age and multi-species, varying size and spatial distribution of compartments (blocks))
	Restoration	• Restoration of natural habitat following degradation to improve habitat condition to pre-impact state • Reforestation to establish corridor function and improve connectivity between extant or restored habitat patches (e.g. riverine areas) • Early and progressive closure and rehabilitation of utilised land incl. revegetation and reforestation
Fragmentation of natural habitat	Avoid	• Alternatives- Engineering solutions, operation plans, infrastructure planning, footprint design • Forego/sterilise resource • Avoid clearance of areas with high densities of fruiting trees • Leave (reserve) trees or groups of trees in the harvest concession for regeneration purposes, and to provide nesting sites, food sources, cover, and travel corridors • Avoid the clearance and degradation of gallery and riparian forest to maintain riverine corridors which provide important connectivity for species
	Minimise	• Establish buffer areas between areas cleared for project activities • Allow canopy closure over roads and other linear clearings • Minimise the number of access and extraction roads in and adjacent to high condition and core habitat and prioritise use of existing routes and already degraded land (e.g. reusing old logging and similar road networks instead of opening up new ones) as long as such “recycling” does not lead to increased damage to forest canopy (Morgan & Sanz, 2007). • Restrict the width of roads to the minimum that will provide the means for efficient and safe transport • Access restrictions to minimise use of road/rail to the maximum extent possible in areas within or adjacent to core areas of species home range

		• "Construct well-designed and -located wildlife crossing sites (as linear corridors) structures (whether arboreal or terrestrial) to allow safer passage for animals. This can help minimise mortality rates and restore connectivity • Create bridges that have multiple access points at various heights to provide different routes across a gap; allowing several animals to cross at different points at the same time helps to avoid bottlenecks in which conflict can occur between family groups or individuals. In the absence of such bridges, single-strand rope bridges can also be effective (Das et al., 2009) • Retain natural bridges (e.g. overhanging tree branches) over gaps (e.g. over a dam, canal or a wide drain) to allow for individuals or groups to cross
	Restoration	• Restoration of natural habitat following degradation to improve habitat condition to pre-impact state • Reforestation to establish corridor function and improve connectivity between extant or restored habitat patches (e.g. riverine areas) • Early and progressive closure and rehabilitation of utilised land including revegetation and reforestation
Soil compaction	Avoid	• Avoid the use of heavy machinery in core areas of species home range
	Minimise	• Keep access roads to the minimum necessary and design routes to avoid sensitive habitat and resources • Require all vehicles to use designated routes to minimise soil compaction of other areas; must be enforced • Establish a buffer between impacted area and key resources (food, nesting trees, water) to minimise the impacts of soil compaction
	Restoration	• Restore compacted soils taking care not to damage root systems of surrounding vegetation
Clearance of mature plantation	Avoid	• Forego harvest of mature plantations to protect habitat (e.g. historical plantations not to be reactivated)
	Minimisation	• Ensure that tree stems removed are temporally and spatially staggered so as to not encompass the entire home range of a species population or group • Limit removal of trees during particular seasons (and on advice of experts) to prevent disturbance during sensitive times of year

		• Encourage individual/s or groups of species to move from trees/area prior to harvest/felling to avoid direct of operation induced injury or mortality • Diversity in plantation stands should be promoted (e.g. multi-age and multi-species, varying size and spatial distribution of compartments (blocks)
	Restoration	• Not applicable
Noise pollution from operations	Avoid	• Temporal and spatial avoidance of impact through redesign of footprint and operational activities
	Minimise	• Changes to operational plan to reduce the duration and timing of noise from operations • Noise & vibration reduction measures, noise barriers • Creating a minimum distance buffer between noise generating activities and sensitive receptors (e.g. from core areas of species home range, but also from key resources such as permanent water sources, nesting trees etc.) • Noise criteria in calls for tenders for equipment and material • Noise criteria /policy in place and enforced for all employees (e.g. through Code of Conduct) and for all contractors (e.g. through contractor contracts) when engaging in activities within or adjacent to species home range • Access restrictions to minimise the use of areas by staff • Traffic management rules / speed limits to reduce noise pollution • Relocate worker accommodation / camps etc. away from species home range. Avoid core area (and buffer) of species home range completely
Light pollution from operations	Avoid	• Spatial avoidance: operational planning and lighting restrictions in certain areas • Temporal avoidance: lighting restrictions during sensitive times of day / year
	Minimisation	• Reduce and control lighting levels at all permanent and temporary facilities e.g. directional lighting to avoid lighting up non-essential areas, use of baffles to limit lit area in sensitive areas
Operation induced injury/mortality	Avoid	• Reroute linear infrastructure (roads, rail, powerlines etc.)
	Minimise	• Strategic road and rail planning to minimise the number of roads/railways (for access, extraction etc) that species must cross in their home range • Utilise existing infrastructure corridors for powerlines etc. • Put in place and enforce strict speed limits on all vehicles; (e.g. <60 km and less or large vehicles – north-west Guinea) • Driver sensitisation to collision and other environmental risks

		• Install signs to alert drivers to the presence of species • Conditions in contracts for (sub-)contractors • Access restrictions to minimise vehicle use in areas within or adjacent to species home range • Speed bumps and other structures to reduce traffic speed • Implement livelihood and awareness programmes to reduce hunting and poaching incidences for subsistence or trade • Construct well-designed and -located wildlife crossing sites (as linear corridors) structures (whether arboreal or terrestrial) to allow safer passage for animals. This can help minimize mortality rates and restore connectivity • Create bridges that have multiple access points at various heights to provide different routes across a gap; allowing several animals to cross at different points at the same time helps to avoid bottlenecks in which conflict can occur between family groups or individuals • Retain natural bridges (e.g. overhanging tree branches) over gaps (e.g. over a dam, canal or a wide drain) to allow for individuals or groups to cross • Allow canopy closure over roads and other linear clearings to maintain habitat continuity and allow for species movement
Dust pollution from operational activities	Avoid	• Avoid deforestation
	Minimise	• Limit vehicle speed • Watering of transportation routes • Water suppression in ore handling • Use of water-spray dust control • Irrigation of material during excavation, blasting and crushing (mining) • Minimise stripping of soils
	Restoration	• Progressive rehabilitation of extraction area (especially in relation to mining)
Human-wildlife conflict	Minimise	• Maximise distance between operations and species habitat to reduce likelihood of species in operational land (especially agricultural) • Select crops that are unpalatable to wild species (e.g. chilli, tea) either as the primary crop or as part of a diversified farm system to minimise crop raiding and human-wildlife conflict • Crop protection measures put in place to minimise crop raiding by species and reduce potential for human-wildlife conflict

		• Guard crops against damage from species with non-violent methods (e.g. through patrolling fields, making noise (shouting or banging objects)), chasing) (Vieira et al., 2019). Tactics to be varied over time to avoid desensitisation though over long-term habituation is likely • Create buffer areas to provide other natural resources across the seasons to minimise crop raiding. Mixed evidence for the effectiveness of this strategy with other great apes as it may also encourage apes closer to cultivated lands • Create buffer zones to discourage species from crossing between natural habitat and cultivated lands (e.g. planting unpalatable species such as tea, chilli or other vegetation they are unlikely to cross). Creation of buffer zone should not involve natural habitat clearance or removal of key resources as this would exacerbate conflict. Buffer zone needs to be wide enough to minimise conflict. Careful selection of crop species is important to avoid the introduction of alien or invasive species, or crops that reduce soil quality, or have other adverse ecological impacts. Consider whether they will be for subsistence or cash generating and dependent on external markets. To be designed in line with site-specific conditions • Sensitisation of all employees and contractors to wildlife encounter risks and protocols (education, awareness-raising and training) • Establish trained wildlife monitoring response teams to monitor wildlife activity In and around operation and respond to incidences of human-wildlife conflict • Strictly enforced policy / code of conduct prohibiting violent behaviour towards wildlife and establishing protocols to support non-violent approaches to encounters with wildlife
Pollution of water resources	Avoid	• Careful spatial planning of infrastructure and activities to avoid pollution of hydrological systems within hydrological basins • Operate closed water cycle systems with no discharge of pollutants or heavy metals • Off-site treatment of all heavy metals and toxins • Protect headwater channels on plateaus or at their edge and linked riparian habitat • No clearance of natural habitat and/or cultivation on steep slopes • No work to be undertaken within specified hydrological buffer zones; green buffer of >X meters to be maintained between watercourses and operation zones to prevent soil erosion • Avoid application of agrochemicals through adoption of organic and integrated farming practises (e.g. mulching, cover cropping)

	Minimise	• Reduce application of agrochemicals through adoption of organic and integrated farming practises (e.g. mulching, integrated pest management, cover cropping) • Employ strategies to minimise dust pollution and its transfer to freshwater surfaces (e.g. restrict vehicle speed in areas near sensitive water courses; surface spraying of transportation routes; etc) • Establish drainage networks with sediment traps • Earthworks scheduled for dry season to limit transfer of sediment into surface water system • Adopt good practice waste management including treatment of polluted water and chemicals • Limit natural habitat clearance for operation/s to minimum necessary to minimise erosion and associated sediment loading in hydrological systems • Relocate worker camps away from springs and other sensitive water sources; treat effluent before returning to environment • Terracing of steep slopes
	Restoration	• Reduce erosion through reforestation • Restoration of riparian habitat • Sequential approach to activities; progressive closure / rehabilitation to limit area of cleared land at any one time; mitigate erosion, run off and related effects
Restricted access to water resources	Avoid	• Infrastructure development must not prevent access to or otherwise affect water sources; this is particularly critical in water stressed environments and should take into account likely impacts of climate change on hydrological systems
	Minimise	• Apply a 'no abstraction' threshold • Minimise use of groundwater by recycling and reuse of wastewater • Maintain habitat corridors to facilitate access to water sources
	Restoration	• Restoration of riparian habitat • Develop thresholds for minimum ecological flow
Visual barriers	Minimise	• Dismantling temporary infrastructure. The dismantling and destruction of temporary infrastructure—such as access roads, provisional camps and bridges
Introduction and spread of alien and invasive species	Minimise	• Source planting material (e.g., seeds, tubers) from reliable suppliers who can provide evidence of purity • Restricted access to areas • Protocols for cleaning and sterilisation of infrastructure and equipment

		• Protocols for management of alien and invasive species
Exposure to disease	Avoid	• "In areas adjacent to infrastructure and ape habitat, strict controls and policies can be effective in preventing the introduction of domestic animals and invasive species, and associated risks of disease transmission to apes."
Fire events	Minimise	• Maintain fire breaks between natural habitat and boundary • Have a fire prevention and response protocol for all fire events in the immediate surrounds of the project
Reduction in soil productivity and quality	Avoid	• Alternatives- Engineering solutions, operation plans, infrastructure planning, footprint design
	Minimise	• Protocols for collection and storage of topsoil
	Restore	• Concurrent restoration to utilise topsoil
Altered drainage networks	Avoid	• Alternative sustainable sources of water • No work to be undertaken within specified hydrological buffer zones; green buffer of >X meters to be maintained between watercourses and operation zones
	Minimise	• Seasonally appropriate abstraction and/or recharge that account for the maintenance of environmental flows • Operate closed water cycle systems
Air emissions	Avoid	• Minimise air emissions to as low as possible through management and alternative energy sources

REFERENCES

Baker, J., Sheate, W. R., Phillips, P., & Eales, R. (2013). Ecosystem services in environmental assessment - Help or hindrance? *Environmental Impact Assessment Review*, *40*(1), 3–13. https://doi.org/10.1016/j.eiar.2012.11.004

Brugiere, D., & Kormos, R. (2009). Review of the protected area network in Guinea, West Africa, and recommendations for new sites for biodiversity conservation. *Biodiversity and Conservation*, *18*, 847–868. https://doi.org/10.1007/s10531-008-9508-z

Ceperley N, Montagnini F, N. A. (2010). (2010). Significance of sacred sites Trop., for riparian forest conservation in Central Benin. *Bois. For.*, *303*(1), 5–23.

Couch, C., Cheek, M., Haba, P., Molmou, D., Williams, J., Magassouba, S., Doumbouya, S., & Diallo, M. Y. (2019). *Threatened Habitats and Tropical Important Plant Areas (TIPAs) of Guinea, West Africa* (Issue June 2020). https://doi.org/10.34885/169

Das, J., Biswas, J., Bhattacherjee, P., & Rao, S. S. (2009). *Canopy Bridges: An Effective Conservation Tactic for Supporting Gibbon Populations in Forest Fragments* (pp. 467–475). https://doi.org/10.1007/978-0-387-88604-6_22

FFI. (2021). *Coordinated and collaborative application of the mitigation hierarchy in complex multi-use landscapes in Africa: Gabon. Industry leadership and multi-stakeholder collaboration to mitigate impacts to high biodiversity values*.

Garrigue, C., Clapham, P., Geyer, Y., Kennedy, A., & Zerbini, A. (2015). Satellite tracking reveals novel migratory patterns and the importance of seamounts for endangered South Pacific humpback whales. *Royal Society Open Science*, *2*, 150489. https://doi.org/10.1098/rsos.150489

International Monetary Fund. (2017). *Economic development documents* (Issue 17).

Kennedy, Christina M., Oakleaf, James M., Theobald, David.M., Baruch-Mordo, Sharon., Kiesecker, J. (2019). Global Human Modification. *Glob Change Biol*, *25*, 811–826. https://doi.org/https://doi.org/10.6084/m9.figshare.7283087.v1

Lebbie, A., & Burgess, P. (2004). Guinean Montane Forests. In J. N. Burgess, E. D'Amico Hales, E. Underwood, D. Dinerstein, I. Olson, J. Itoua, T. Schipper, Ricketts, & K. Newman (Eds.), *Terrestrial Ecoregions of Africa and Madagascar: A Conservation Assessment*. Island Press.

Leha, M.D.K; Matlocka, D.M., Cummings, E.C., L. L. (2013). Quantifying and mapping multiple ecosystem services change in West Africa. *Agriculture, Ecosystems and Environment*, *165*(2013), 6–18.

Morgan, D., & Sanz, C. (2007). *Best practice guidelines for reducing the impact of commercial logging on great apes in Western Equatorial Africa* (No. 34; Occassional Paper of the IUCN Species Survival Commission, Issue 34). https://doi.org/10.2305/iucn.ch.2007.ssc-op.34.en

Nations Encyclopedia. (2021). *Guinea - Agriculture*. https://www.nationsencyclopedia.com/Africa/Guinea-AGRICULTURE.html#ixzz6OINLpwbg

Norris, K., & Fitter, A. (2011). Biodiversity and ecosystem services: a multilayered relationship. *Trends in Ecology & Evolution*, *27*, 19–26. https://doi.org/10.1016/j.tree.2011.08.006

Republic of Guinea Ministry of Mines and Geology. (2021). *Mining-infrastructure synergies, Growth corridors*. https://mines.gov.gn/en/priorities/infrastructure/

Smith, V. H. & Schindler, D. W. (2009). Eutrophication science: where do we go from here? *Trends in Ecology and Evolution*, *24*, 201–207.

Takouleu, J. M. (2019). *Sinohydro to build the 294 MW Koukoutamba hydroelectric dam*. Afrik21. https://www.afrik21.africa/en/guinea-sinohydro-to-build-the-294-mw-koukoutamba-hydroelectric-dam/

UNEP-WCMC. (2021). *Protected Area Profile for Guinea from the World Database of Protected Areas*. Protected Planet. https://www.protectedplanet.net/country/GIN

Vieira, W. F., Kerry, C., & Hockings, K. J. (2019). A comparison of methods to determine chimpanzee home - range size in a forest – farm mosaic at Madina in Cantanhez National Park , Guinea - Bissau. *Primates*, *60*(4), 355–365. https://doi.org/10.1007/s10329-019-00724-1

Wild Chimpanzee Foundation. (2018). *Annual Report 2018 Activities of the Wild Chimpanzee Foundation for improved Table of c ontents* (Issue January 2019).

World Bank Group. (2018). *Guinea Rural Mobility and Connectivity Project*.

DATA SOURCES

DATA LAYER	DESCRIPTION	SOURCE	REFERENCE	LINK TO DATA
Conservation Areas	All nationally declared and legally protected or internationally recognised conservation areas, including National Parks, Classified Forest Reserves, Wildlife Management Areas, Faunal Reserves, Nature Reserves, Hunting Areas and Reserves, Ramsar Wetlands of International Importance, World Heritage Sites and UNESCO Man and Biosphere Reserves. Proposed Protected Areas in Liberia have been accessed through the Forestry Development Authority.	World Database on Protected Areas (WDPA), Forest Development Authority Liberia (FDA)	UNEP-WCMC and IUCN (2020), Protected Planet: The World Database on Protected Areas (WDPA) [On-line], Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net. Liberia Forest Atlas (2019). Dynamic forest monitoring system for Liberia's forest sector: Protected Areas. [ONLINE]. https://lbr.forest-atlas.org/.	https://www.protectedplanet.net/ http://lbr-data.forest-atlas.org/
Key Biodiversity Areas	Sites of global importance to the planet's overall health and the persistence of biodiversity, either coinciding with declared conservation areas or external to the protected area network and supported by the Key Biodiversity Areas Partnership.	Key Biodiversity Areas Partnership	Key Biodiversity Areas Partnership (2020). Developed by the Key Biodiversity Areas Partnership: BirdLife International, IUCN, American Bird Conservancy, Amphibian Survival Alliance, Conservation International, Critical Ecosystem Partnership Fund, Global Environment Facility, Global Wildlife Conservation, NatureServe, Rainforest Trust, Royal Society for the Protection of Birds, World Wildlife Fund and Wildlife Conservation Society.	http://www.keybiodiversityareas.org/

Land cover	Classified land cover representing the year 2016 at 20m resolution based on 1 year of Sentinel-2A imagery from December 2015 to December 2016. The following land cover classes describe the land surface across the African continent: "trees cover areas", "shrubs cover areas", "grassland", "cropland", "vegetation aquatic or regularly flooded", "lichen and mosses / sparse vegetation", "bare areas", "built up areas", "snow and/or ice" and "open water". In this project's application, this layer has been correlated with the Global Forest Watch forest cover and forest loss layers to update the land cover to the current year 2020.	European Space Agency (ESA)	European Space Agency Climate Change Initiative (2016) "S2 Prototype Land Cover 20m Map of Africa 2016". European Space Agency.	http://2016africalandcover20m.esrin.esa.int/
Tree coverage	Global measure of tree cover percentage at approximately 30 × 30 metre resolution and derived from Landsat imagery for the periods 2000 and 2010. Tree cover is defined as all vegetation greater than 5 meters in height and may take the form of natural forests or plantations across a range of canopy densities.	Hansen/University of Maryland (UMD)/Google/ United States Geological Survey (USGS)/National Aeronautics and Space Administration (NASA), accessed through Global Forest Watch	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342: 850–53.	https://glad.umd.edu/dataset/global-2010-tree-cover-30-m
Tree height	Global measure of tree canopy maximum height (in metres) at approximately 30 x 30 metre resolution using lidar forest structure measurements and Landsat imagery for the year 2019.	Hansen/University of Maryland (UMD)/National Aeronautics and Space Administration (NASA), accessed through Google Earth Engine	P. Potapov, X. Li, A. Hernandez-Serna, A. Tyukavina, M.C. Hansen, A. Kommareddy, A. Pickens, S. Turubanova, H. Tang, C.E. Silva, J. Armston, R. Dubayah, J. B. Blair, M. Hofton (2020) Mapping and monitoring global forest canopy height through integration of GEDI and Landsat data. Remote Sensing of Environment, 112165.	https://glad.umd.edu/dataset/gedi

Habitat function	To perform habitat function connectivity analysis on the land cover layer, Morphological Spatial Pattern Analysis was utilised. Using the connectivity classes of core habitat, edge habitat and bridge habitat, the tool assesses the shape, size and distance of habitat patches using simple mathematical operators. All land cover classes of forest and flooded vegetation were integrated in the habitat layer to which the connectivity was performed.	Joint Research Centre (JRC)	Ostapowicz, K., Vogt, P., Riiters, K. H., Kozak, J. & Estreguil, C. (2008). Impact of scale on morphological spatial pattern of forest. Landscape Ecology, 23:1107–1117.	https://forest.jrc.ec.europa.eu/en/activities/lpa/mspa/
Forest loss	Global measures of tree cover loss at approximately 30 × 30 metre resolution and derived from yearly composites of Landsat imagery. Tree cover loss is defined as "stand replacement disturbance," or the complete removal of tree cover canopy at the Landsat pixel scale. Tree cover loss may be the result of human activities, including forestry practices such as timber harvesting or deforestation, as well as natural causes such as disease, storm damage or fire.	Hansen/University of Maryland (UMD)/Google/ United States Geological Survey (USGS)/National Aeronautics and Space Administration (NASA), accessible via Global Forest Watch	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342: 850–53.	http://earthenginepartners.appspot.com/science-2013-global-forest
Great ape population density: Central chimpanzee and Western lowland gorilla	Modelled estimated population density values per square kilometre for Central chimpanzee and Western lowland gorilla across their geographic range. Various spatial variables were utilised in the modelling of population densities, including predictor variables derived from site-specific surveys, habitat variables, environmental gradients and anthropogenic and vulnerability variables.	Strindberg *et al.* (2018)	Strindberg, S., Maisels, F., Williamson, E. A., Blake, S., Stokes, E. J., Aba'a, R., … Wilkie, D. S. (2018). Guns, germs, and trees determine density and distribution of gorillas and chimpanzees in Western Equatorial Africa. Science Advances, 4(4). https://doi.org/10.1126/sciadv.aar2964	https://doi.org/10.1126/sciadv.aar2964

Great ape population density: Western chimpanzee	Modelled estimated population density values per square kilometre for Western chimpanzee across its geographic range. Various spatial variables were utilised in the modelling of population densities, including predictor variables derived from site-specific surveys, habitat variables, environmental gradients and anthropogenic and vulnerability variables.	Heinicke *et al.* (2019)	Heinicke, S., Mundry, R., Boesch, C., Amarasekaran, B., Barrie, A., Brncic, T., … Kühl, H. S. (2019). Advancing conservation planning for western chimpanzees using IUCN SSC A.P.E.S.—the case of a taxon-specific database. Environmental Research Letters, 14(6), 064001.	https://doi.org/10.1088/1748-9326/ab1379
Habitat suitability	Modelled habitat suitability for Western chimpanzee, African forest elephant and pygmy hippopotamus within the Upper Guinea lowland rainforest extent of West Africa. Derived from analysis using Maxent models and predictor variables of a combination of georeferenced species occurrence data and environmental data, including climatic variables, vegetation and habitat types and precipitation.	Freeman *et al.* (2019)	Freeman, B., Roehrdanz, P. R., & Peterson, A. T. (2019). Modeling endangered mammal species distributions and forest connectivity across the humid Upper Guinea lowland rainforest of West Africa. Biodiversity and Conservation, 28(3), 671–685.	https://doi.org/10.1007/s10531-018-01684-6
Suitable corridors for connectivity	Modelled suitable corridors for Western chimpanzee, African forest elephant and pygmy hippopotamus within the Sapo-Tain and Gola-Ziama forest complexes in West Africa. The least-cost path routes between the established and proposed protected areas within the focal areas were derived from modelling species' dispersal variables and habitat suitability using Circuitscape, Linkage Mapper and Pinchpoint Mapper.	Freeman *et al.* (2019)	Freeman, B., Roehrdanz, P. R., & Peterson, A. T. (2019). Modeling endangered mammal species distributions and forest connectivity across the humid Upper Guinea lowland rainforest of West Africa. Biodiversity and Conservation, 28(3), 671–685.	https://doi.org/10.1007/s10531-018-01684-6
Granted mining claims	Global mining concession dataset, based on the ground covered by a polygon that has been set aside for an activity to take place. This activity could be mining exploration and/or extraction. The dataset utilised in this project is the publically available version, where no interrogation of the data is possible.	SNL Metals & Mining	SNL Metals & Mining, an offering of S&P Global Market Intelligence (2020)	https://panda.maps.arcgis.com/home/item.html?id=6f8e17219c354878af009a6cc9a9f571

Awarded oil and gas concessions	Global oil and gas concession dataset on the location, type, dates and participating companies for all the oil & gas licensed acreage. It also includes applications and some open acreage where country grids defined. The dataset utilised in this project is the publically available version, where no interrogation of the data is possible.	Drilling Info	Copyright Drilling Info, Inc. (2020)	https://panda.maps.arcgis.com/home/item.html?id=2eba17ff88924fa0b08a5c360442ec59
Forestry licenses	Polygons representing the extent of known and active forestry licenses derived from a variety of sources within each of the focal countries.	Liberia: AidData Gabon: Ministry of Forest Economy, Water, Fisheries, and Aquaculture & World Resources Institute	Bunte, Jonas B., Harsh Desai, Kanio Gbala, Brad Parks, Daniel Miller Runfola. 2017. Natural Resource Sector FDI and Growth in Post-Conflict Settings: Subnational Evidence from Liberia. AidData Working Paper #34. Williamsburg, VA: AidData. "Managed forest concessions." Accessed through Global Forest Watch (2020)	https://www.aiddata.org/data/liberia-concessions-geocoded-research-release-level-1-v-1-0 https://www.globalforestwatch.org
Community forests	Communal Forests are areas set aside by statute or regulation for the sustainable use of forest products by local communities or tribes on a non-commercial basis in Liberia. According to the National Forestry Reform Law of 2006, no prospecting, mining, settlement, farming or commercial timber extraction is permitted on community forests.	Liberia: AidData	Bunte, Jonas B., Harsh Desai, Kanio Gbala, Brad Parks, Daniel Miller Runfola. 2017. Natural Resource Sector FDI and Growth in Post-Conflict Settings: Subnational Evidence from Liberia. AidData Working Paper #34. Williamsburg, VA: AidData.	https://www.aiddata.org/data/liberia-concessions-geocoded-research-release-level-1-v-1-0
Private Use Permits	Private Use Permit refers to a type of framework agreement in Liberia, established in 2006, allowing private individuals to sign contracts with companies for extractive activities. They are approved by the Forest Development Authority. This data set was compiled by AidData who collected the information from Global Witness and the Sustainable Development Institute.	AidData	Bunte, Jonas B., Harsh Desai, Kanio Gbala, Brad Parks, Daniel Miller Runfola. 2017. Natural Resource Sector FDI and Growth in Post-Conflict Settings: Subnational Evidence from Liberia. AidData Working Paper #34. Williamsburg, VA: AidData.	https://www.aiddata.org/data/liberia-concessions-geocoded-research-release-level-1-v-1-0

Oil palm concessions	Displays boundaries of areas of known oil palm plantations for Liberia, compiled by Global Witness from available government maps. Information provided with this data set includes company, ownership group, and land area.	Global Witness	"Oil palm concessions." Accessed through Global Forest Watch	https://www.globalforestwatch.org
RSPO oil palm concessions	This data layer displays the concession boundaries of Roundtable on Sustainable Palm Oil (RSPO) member companies current to the year end 2020, including both certified and non-certified concessions, as well as concessions where the certification status is unknown. The concession boundaries were provided to the RSPO by member companies.	Roundtable on Sustainable Palm Oil (RSPO) Member Companies	RSPO (2020) RSPO Concession. Spatial dataset available from GeoRSPO.	https://rspo.org/members/georspo
Human modification gradient	The global Human Modification map provides a cumulative measure of human modification of terrestrial lands across the globe for the year 2016 at a 1-km resolution. It is a continuous 0-1 metric that reflects the proportion of a landscape modified based on modelling the physical extents of 13 anthropogenic stressors and their estimated impacts using spatially-explicit global datasets with a median year of 2016.	Kennedy *et al.* (2019)	Kennedy, C. .M, Oakleaf, J. R., Theobald, D. M., Baruch-Mordo, S., Kiesecker, J. (2019) Managing the middle: A shift in conservation priorities based on the global human modification gradient. Glob Change Biol. 25:811–826.	https://doi.org/10.1111/gcb.14549
Priority groundwater recharge subwatersheds	Hydrologic ecosystem services priority areas are sub-regions of the country that provide the highest levels of water quantity and quality benefits to people in both urban and rural communities. The assessment focussed on Gabon and modelled the priority subwatershed areas that provide the greatest benefit and support to groundwater recharge processes.	Goldstein *et al.* (2017)	Goldstein, J. H., Tallis, H., Cole, A., Schill, S., Martin, E., Heiner, M., ... Barry Nickel3. (2017). Spatial planning for a green economy: National-level hydrologic ecosystem services priority areas for Gabon. PLoS ONE, 12(6), 1–21.	https://doi.org/10.1371/journal.pone.0179008

Aboveground biomass	Modelled terrestrial aboveground live woody biomass density (megagrams biomass ha-1)at approximately 30-meter resolution for the year 2000, expanding on the methodology presented in Baccini et al. (2012). The data are AGB density values (megagrams biomass/hectare), where aboveground carbon density values can be estimated as 50 percent of biomass density values.	Woods Hole Research Center, Zarin	Woods Hole Research Center. Unpublished data. Accessed through Global Forest Watch Climate	https://www.climate.globalforestwatch.org
Population density	Modelled estimates of the total number of people per square grid across continental Africa, with national totals adjusted to match UN population division estimates and revised to depict year 2012.	WorldPop	United Nations (2015) 'World Population Prospects'	http://esa.un.org/wpp/
Administrative borders	Global administrative data of the international country boundaries and regional boundaries of Guinea, Liberia, Sierra Leone and Gabon.	Global Administrative Areas (GADM)	Global Administrative Areas (2019). GADM database of Global Administrative Areas, version 2.0. [ONLINE] URL: www.gadm.org.	https://gadm.org/
Road network	The Global Roads Inventory Project (GRIP) dataset was developed to provide a more recent and consistent global roads dataset, consisting of global and regional vector datasets in ESRI file geodatabase and shapefile format and derived from a variety of sources including OpenStreetMap.	Global Roads Inventory Project (GRIP) 4	Meijer, J.R., Huijbegts, M.A.J., Schotten, C.G.J. and Schipper, A.M. (2018) Global patterns of current and future road infrastructure. Environmental Research Letters, 13-064006.	www.globio.info
Railway network	The railway key is a label from OpenStreetMap which aims to map and document all types of railways including light rail, mainline railways, metros, monorails and trams.	Open Street Map	Open Street Map. "Key: Railway".	https://wiki.openstreetmap.org/wiki/Planet.osm

Satellite imagery	Imagery of terrain based on various years and imagery sources	Esri, DigitalGlobe, GeoEye, i-cubed, United State Department of Agriculture and Food and Drug Administration (USFDA), Farm Service Agency (FSA), United States Geological Survey (USGS), Aerials Express (AEX), Getmapping, Aerogrid, Institut national de l'information géographique et forestière (IGN), Portuguese Geographic Institute (IGP), swisstopo, and the GIS User Community	Various sources and dates, World Imagery. ESRI.	https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9

Coordinated and collaborative application of the mitigation hierarchy in complex multi-use landscapes in Africa: Guinea Central Corridor

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